



# STATEMENT

I, Hideyuki ISOBE, of c/o NGB CORPORATION, Toranomon East Bldg. 7-13, Nishi-Shinbashi 1-chome, Minato-ku, Tokyo 105-8408 Japan, hereby state that I have a thorough knowledge of the English and Japanese languages and that the attached documents are accurate English translation of the Japanese specification of Japanese Patent Application Hei.8-188347 filed June 28, 1996 upon which the present application claims a priority.

Declared at Tokyo, Japan

This 17th day of February, 2009

A handwritten signature in cursive script, appearing to read "H. Isobe".

Hideyuki ISOBE

**Patent Office**  
**Japanese Government**

This is to certify that the annexed is a true copy of the following application as filed with this Office.

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Application Number : Pat. Hei. 8-188347

Applicant(s) : NGK SPARK PLUG CO., LTD.

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Commissioner,  
Patent Office Hisamitsu Arai

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[Filed Document Name]	Specification      1
[Filed Document Name]	Drawing            1
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(Name of Document) Specification

(Title of Invention) Spark plug

(Claims)

1. A spark plug comprising a central electrode, an insulator provided exterior to said central electrode, a main metallic shell provided exterior to said insulator while projecting said central electrode from one end portion, a grounded electrode coupled at one end to said main metallic shell and which has the other end disposed to face said central electrode, and an igniting portion that is secured to either said central electrode or said grounded electrode or both for forming a spark discharge gap, wherein said igniting portion is made of a chip which contains Rh in an amount ranging from 10 to 70 wt%, and the balance substantially composed of Ir.

2. A spark plug according to claim 1, wherein the alloy of said chip contains Rh in an amount ranging from 20 to 60 wt%.

3. A spark plug according to claim 1, wherein the alloy of said chip contains Rh in an amount ranging from 30 to 40 wt%.

(Detailed Description of Invention)

(Technical Field of the Invention)

The present invention relates to a spark plug for use on internal combustion engines.

(Prior Art)

Conventional spark plugs for use on internal combustion engines such as automotive engines have the igniting portion formed of a platinum (Pt) alloy chip welded to the distal end of an electrode in order to improve its resistance to spark consumption. However, in view of the high cost of platinum, it has been proposed to use less expensive iridium (Ir) as a chip material.

(Problem to be Solved by the Invention)

A problem with the use of Ir as a material to constitute the igniting portion of the spark plug is that Ir is easy to oxidize and evaporate in a high temperature range of 900 to 1,000°C and that, therefore, if it is directly used in the igniting portion of the electrode, it is more consumed by oxidation and evaporation than by spark. Therefore, the spark plug using Ir in the igniting portion of an electrode is highly durable under low-temperature conditions as in cruising on city roads but their endurance drops considerably during continuous running at high speed.

An object, therefore, of the invention is to provide a spark plug that has the igniting portion chiefly made of Ir and which yet is sufficiently resistant to consumption by oxidation and evaporation of the Ir component at elevated temperatures to assure high endurance not only during cruise on city roads but also during continuous running at high speed.

(Means for solving the problem, mode of its action and the

resulting advantages)

In order to solve the above problems, a spark plug according to the present invention comprises a central electrode, an insulator provided exterior to said central electrode, a main metallic shell provided exterior to said insulator while projecting said central electrode from one end portion, a grounded electrode coupled at one end to said main metallic shell and which has the other end disposed to face said central electrode, and an igniting portion that is secured to either said central electrode or said grounded electrode or both for forming a spark discharge gap, wherein said igniting portion is made of a chip which contains Rh in an amount ranging from 10 to 70 wt%, and the balance substantially composed of Ir. Incidentally, "the balance substantially composed of Ir" means to allow to contains about 0.3 wt% of impurities.

The present inventors have found that if the igniting portion of an electrode which forms a spark discharge gap is made of an alloy that is chiefly made of Ir and which contains an amount of Rh in the stated range, the consumption due to oxidation and evaporation of the Ir component at elevated temperatures is effectively retarded to thereby realize a highly durable spark plug.

If the Rh content of the alloy is less than 10%, the effectiveness of Rh in retarding the oxidation and evaporation of Ir is insufficient to prevent premature consumption of the

igniting portion and, hence, the endurance of the spark plug is reduced. If, on the other hand, the Rh content of the alloy is 70 wt% or more, the melting point of the alloy will drop and the endurance of the spark plug will deteriorate accordingly.

Therefore, the Rh content of the alloy is preferably adjusted to lie within the range of 20 to 60 wt%, desirably 30 to 40 wt%.

(Embodiments of the Invention)

Several embodiments of the invention will now be described with reference to the accompanying drawings.

Fig. 1 shows an embodiment of the invention, in which the spark plug generally indicated by 100 comprises basically a tubular main metallic shell 1, an insulator 2 fitted into the metallic shell 1 in such a way that the distal end 21 protrudes from the metallic shell 1, a central electrode 3 provided within the insulator 2 in such a way that the igniting portion 31 formed at the distal end protrudes from the insulator 2, and a grounded electrode 4 coupled at one end to the main metallic shell 1 as by welding and which has the other end bent laterally such that its lateral side faces the distal end of the central electrode 3. The grounded electrode 4 has an igniting portion 32 formed in such a way that it faces the igniting portion 31 of the central electrode 3; the clearance between the two igniting portions 31 and 32 forms a spark discharge gap g.

The insulator 2 is a sinter of a ceramic material such as alumina or aluminum nitride and it has an axial bore 6 through

which the central electrode 3 is to be fitted. The main metallic shell 1 is a cylinder made of a metal such as a low-carbon steel and which provides a housing for the spark plug 100. The circumference of the fitting 1 has a threaded portion 7 formed to assist in the mounting of the spark plug 100 on an engine block (not shown).

The main body 3a of the central electrode 3 and the main body 4a of the grounded electrode 4 are both typically made of a Ni alloy. The igniting portion 31 of the central electrode 3 and the opposed firing portion 32 of the grounded electrode 4 are both made of an alloy based on Ir and which contains Rh in an amount ranging from 10 to 70 wt%. The Rh content of the alloy is desirably adjusted within a range of 20 to 60 wt%, more desirably 30 to 40 wt%. The chips may be formed from a molten material obtained by mixing the necessary alloy ingredients to give the stated formula and melting the mixture; alternatively, the chips may be formed from a sinter obtained by shaping into a compact a suitable alloy powder or a mixture of the powders of elemental metal components in specified proportions and sintering the compact.

As shown enlarged in Fig. 2, the main body 3a of the central electrode 3 tapers at the distal end and its distal end face is formed flat. A disk-shaped chip having an alloy formula for the igniting portion 31 is placed on the flat distal end face and laser welding, electron beam welding, resistance welding or other suitable welding technique is applied to the periphery of the

joined surfaces to form a weld line W, whereby the chip is securely fixed to the distal end face of the central electrode 3 to form the igniting portion 31. To form the opposed igniting portion 32, a similar chip is placed on the grounded electrode 4 in registry with the position of the igniting portion 31 and a weld line W is similarly formed on the periphery of the joined surfaces, whereby the chip is securely fitted to the grounded electrode 4 to form the igniting portion 32. Incidentally, one of the ignition portions 31, 32 can be omitted. In this case, the ignition discharge gap g is formed between the ignition portion 31 or the ignition portion 32 and the ground electrode 4 or the central electrode 3.

The spark plug 100 operates according to the following mode of action. The spark 100 is fitted on an engine block by means of the threaded portion 7 and used as a source to ignite an air-fuel mixture that is supplied into the combustion chamber.

The igniting portion 31 and the opposed igniting portion 32 define the spark discharge gap g; since both igniting portions are made of the aforementioned alloy, their consumption due to the oxidation and evaporation of Ir is sufficiently retarded to ensure that the spark discharge gap g will not increase for a prolonged period, thereby extending the life of the spark plug 100.

(Examples)

(Example 1)

Specified amounts of Ir and Rh were mixed and melted to

prepare alloy samples containing various amounts of Rh in the range of 0 to 80 wt%, with the balance being substantially composed of Ir (comparative samples: Rh = 0 and 80 wt%). The samples of chips of 0.7 mm in diameter and 0.5 mm in thickness were prepared. A chip prepared from a molten alloy consisting of 13 wt% IR and the balance Pt was also fabricated as a comparison. The thus fabricated chips were used to form the igniting portion 31 of the spark plug 100 and the opposed igniting portion 32 (to provide a spark discharge gap  $g$  of 1.1 mm). The individual plugs were subjected to performance tests under the following conditions. Condition A (simulating continuous running at high speed):

A six-cylinder gasoline engine (piston displacement = 3,000 cc) was fitted with the plug under test and operated continuously at full throttle for 300 h at a rotational speed of 6,000 rpm (with the temperature of the central electrode rising to about 900°C); after the engine operation, the increase in the spark discharge gap  $g$  on the plug was measured. The result is shown in Fig. 3 in terms of the relationship between the Rh content of the alloy and the increase in the spark discharge gap.

Condition B (simulating cruising on city roads):

A four-cylinder gasoline engine (piston displacement = 2,000 cc) was fitted with the plug under test and operated for 1,000 h through cycles, each consisting of 1-min idling, 30-min running at full throttle and a rotational speed of 3,500 rpm and 20-min running at half throttle and a rotational speed of 2,000

rpm, with the temperature of the central electrode rising to about 780°C; after the engine operation, the increase in the spark discharge gap  $g$  on the plug was measured. The result is shown in Fig. 4 in terms of the relationship between the Rh content of the alloy and the increase in the spark discharge gap.

The result of the test under condition B indicates that the plugs using chips made of alloy formulae within the range of the invention experienced only small increases in the spark discharge gap  $g$  whereas the comparative plugs (Rh = 80 wt%, and Pt-Ir alloy) had the spark discharge gap increased markedly. The difference the invention samples had with respect to the comparisons was more pronounced under condition A of a higher load than condition B. In particular, the plugs using chips containing 30 to 40 wt% of Rh exhibited a very high level of endurance in spite of the hostile operating condition.

(Brief Description of the Drawings)

Fig. 1 is a partial front sectional view of the spark plug of the invention;

Fig. 2 is a sectional view showing enlarged the essential part of the same spark plug;

Fig. 3 is a graph showing the relationship between the Rh content of the alloy forming the igniting portions of the spark plug and the increase in the spark discharge gap (in Example 1 under condition A);

Fig. 4 is a graph showing the relationship between the

Rh content of the alloy forming the igniting portions of the spark plug and the increase in the spark discharge gap (in Example 1 under condition B).

(key to Symbols)

- 1 ... main metallic shell
- 2 ... insulator
- 3 ... central electrode
- 4 ... grounded electrode
- 31 ... igniting portion (chip)
- 32 ... opposed igniting portion (chip)
- g ... spark discharge gap

(Name of Document)    Abstract

(Summary)

(Object)                To provide a spark plug that has the igniting portions chiefly made of Ir and which yet is sufficiently resistant to consumption by oxidation and evaporation of the Ir component at elevated temperatures to assure high endurance.

(Means of Solution)    Spark plug 100 comprises central electrode 3, insulator 2 provided exterior to the central electrode, main metallic shell 1 provided exterior to the insulator 2 in such a way that the central electrode 3 protrudes from one end, and grounded electrode 4 coupled at one end to the main metallic shell 1 and which has the other end disposed to face the central electrode 3, with chip 31 or 32 being secured to either the central electrode 3 or the grounded electrode 4 or both to form spark discharge gap g. The chip 31 or 32 is made of a metal based on Ir which contains Rh in an amount ranging from 1 to 70 wt%.

(Diagram to be Selected)    Fig. 1

FIG.1

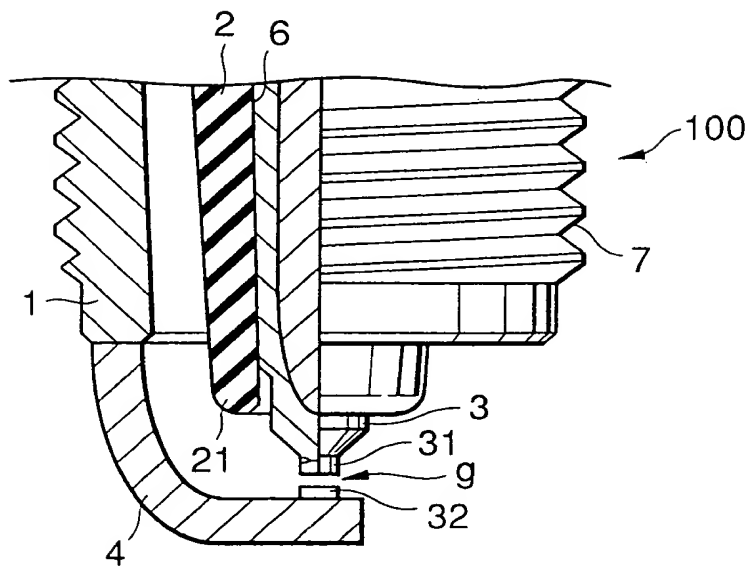
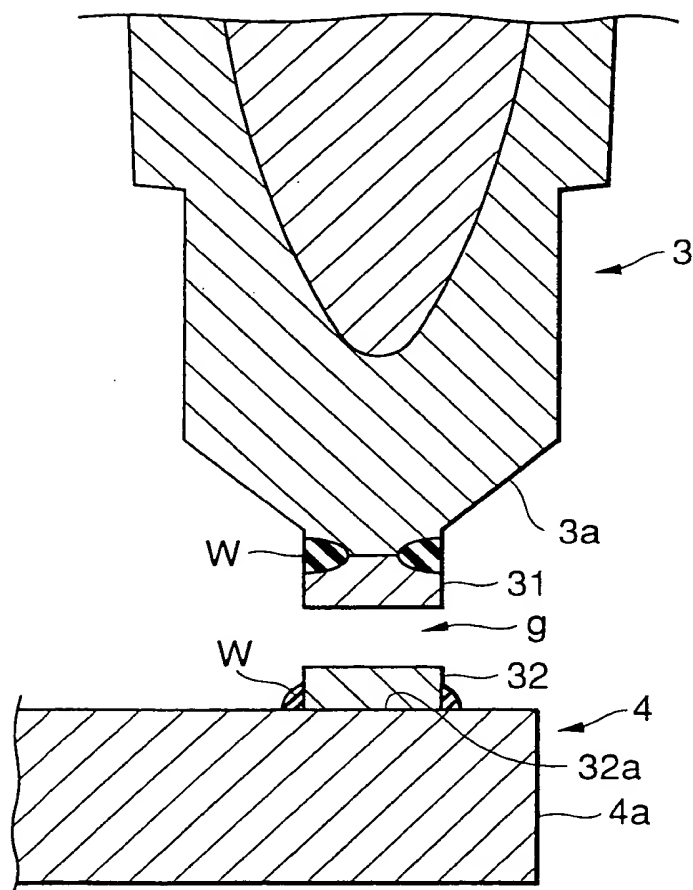
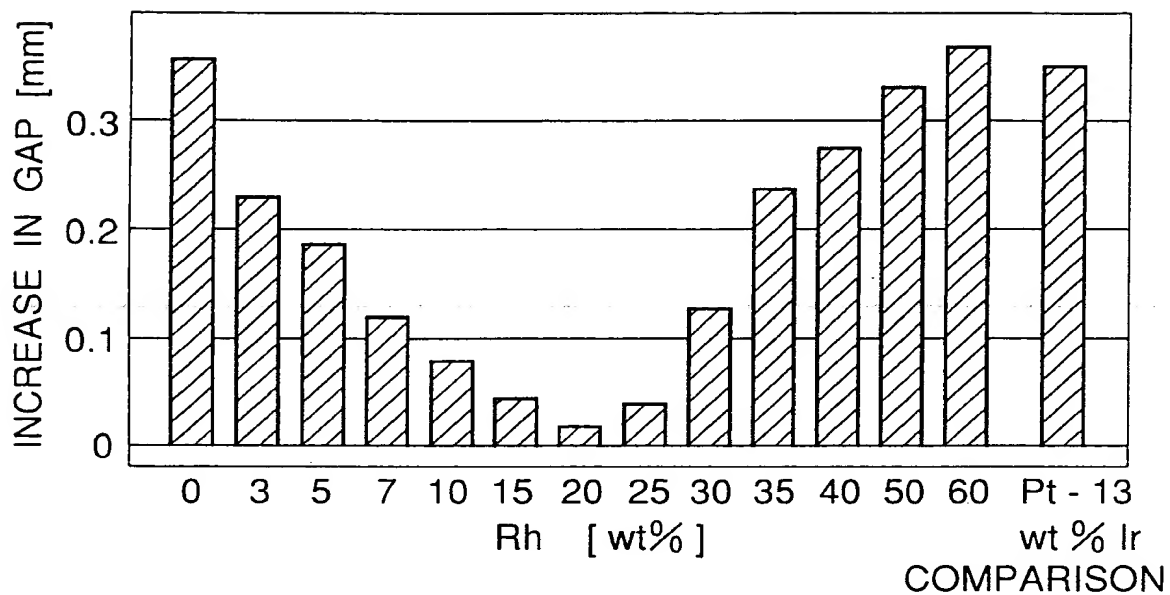


FIG.2



# FIG.3



# FIG.4

